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VARIATION OF SORPTIVITY IN DIVERSE GRADES OF CONCRETE PROPORTIONED WITH FLY ASH, WOODHUSK ASH AND RICE HUSK ASH

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Abstract: The durability and sustainability of concrete structures is a prime socio-economic bother of modern-day society. Current practice considers the attribute, primarily on concrete strength. It has been suggested that the quality of concrete should be depicted not only by strength but also its durability characteristics. The enactment of concrete is greatly affected by its acquaintance with aggressive environments, more precisely its transport properties. The lifecycle of these concrete structures is typically determined by the rate of moisture ingress, in which dissolved and unwanted substances are transported into the structure. Therefore finding a sufficient means to measure these rates is of utmost prominence. Sorptivity testing could be used to assess the durability of concrete against freeze-thaw deterioration. A sorptivity testing scheme as outlined by a commonly used standard can be a useful means of measuring how quickly liquid can be transported unidirectionally through concrete samples in the laboratory. Lower sorptivity sign posts good quality of concrete. The intention of the paper is to contrast sorptivity property of crusher dust used concrete of M25, M30, M35 mix designs with various ingredients(fly ash, wood husk ash, rice husk ash) termed as *Type1, Type2, Type3, Type4.and concrete with cement replaced with wood ash(i.e. Type3) has low sorptivity values compared to other types.

*Type1: 100% Cement , crusher sand, coarse aggregate.
Type2: (90%Cement +10% of cement replaced by weight with fly ash), crusher dust and coarse aggregate
Type3: (90%Cement +10% of cement replaced by weight with wood husk ash),crusher sand and coarse aggregate
Type4: (90%Cement + 10% of cement replaced by weight with rice husk ash),crusher sand and coarse aggregate

Keywords: Sorptivity, flyash,woodhusk ash, rice husk ash.

INTRODUCTION

Concrete is the most important element of the infrastructure and well-designed concrete can be a durable construction material. The durability of concrete is a major consideration in its application in aggressive environments for long service life. The importance of environmental condition on concrete structures should not be overlooked during the design phase. Often, concrete strength has been considered a surrogate for durability. Unfortunately, it is becoming apparent that this is not particularly true due to the rising costs for concrete maintenance all over the world. In recent years, there is a growing interest in the use of high-performance concretes, which provide overall durability and high strength. One method of estimating the durability of a porous material is by measuring the rate at which a fluid, gas or liquid permeates through the material under a given head of pressure (Permeability). Therefore, the measurements of the permeability of concrete were used as an indication of durability. The more quickly a fluid moves through the material, higher permeability, the lower anticipated durability. Similarly, if a fluid moves through the material at a very slow rate, low permeability, a high durability would be expected. It is concluded that permeability is the key to all durability problems. It should also be kept in mind that concretes with identical strength provide the same permeability.

Recently, there is a strong interest in finding better ways of assessing the properties of concretes through determining its durability. As the processes of deterioration in concrete are mediated largely by water, it would be useful to find a way of measuring a single as well as simple material property which can reliably reflect the ability of a material to absorb and transmit water by capillarity. Due to incomplete compaction; concrete may form gel pores & capillary pores, which lead to low strength of concrete. Due to problems associated with the absorption and permeability tests, which measure the response of concrete to pressure, which is rarely the driving force of fluids entering into concrete; hence there is a need for another type of test. Such tests should measure the rate of absorption of water by capillary suction; “sorptivity” of unsaturated concrete. Sorptivity test was found to be an easy and quick test to measure the material property that characterizes the tendency to absorb and transmit water by capillarity. Also, it was found to be directly related to permeability.

It determines the capability of an unsaturated concrete to water penetration by absorption when no head of water exist. Accordingly, minimizing sorptivity is important in order to reduce the ingress of chloride or sulfate into concrete. Sorptivity, or capillary suction, is the transport of liquids in porous solids due to surface tension acting in capillaries and is a function of the viscosity, density, surface tension of the liquid, and also the pore structure of the porous solid. It is measured as the rate of uptake of water. The curing condition was found to be a major issue which affects the variation of the sorptivity test results and consequently the reproducibility of the test. Sufficient curing is essential for concrete to provide its potential performance. It has generally been accepted that curing is more important for concrete with mineral admixtures than for normal concrete, as the pozzolanic reaction between amorphous silica (in mineral admixture) and calcium hydroxide (liberated during cement hydration) needs water to continue. Also, water curing has more effect on the sorptivity than on the strength of concrete

LITERATURE REVIEW

The rate of absorption of water by capillary suction, “sorptivity” of unsaturated concrete replaced cement with certain 20% of fly ash and mix design was carried out for M25 and M40 grade concrete based on limited experimental investigation concerning the water absorption and sorptivity of concrete concluded that the water absorption and sorptivity of fly ash concrete shows lower water absorption and sorptivity at 10% replacement with fly ash for M25 and M40 grade concrete. Also the water absorption and sorptivity of fly ash concrete shows higher water absorption and sorptivity than traditional concrete and the water absorption and sorptivity of M25 fly ash concrete is lower water absorption and sorptivity than M40 grade concrete [1].

The importance of effective sealant in determining sorptivity is the emphasis when paraffin wax for half of concrete samples and tape for the rest of the samples are used and observed that samples of tape sealant shows high sorptivity values compared that of paraffin wax sealant samples and conclusions are made that paraffin wax is the effective sealant compared to tape. Specimens coated in wax typically exhibited lower absorption values than those wrapped in tape since the tape would not adhere perfectly with the concrete at the edge formed by the cylindrical wall and the exposed surface, resulting in increased sorptivity values. The waxed samples yielded more reliable results primarily because they did not absorb moisture artificially along the sides in the manner as observed in the taped specimens. when performed various freezing thawing cycles it showed sorptivity results among electrical insulation tape, cellophane and paraffin wax, the paraffin wax is the effective one [2].

Influence of fly ash on sorptivity of OPC-Fly Ash concrete using a mix proportion of cement (1) sand (1.57): 10 mm aggregates (1.35) : 20 mm aggregates (2.03) with four water to cementitious material (Cement + Fly Ash) ratios (w/cm) (0.55, 0.475, 0.40 and 0.340). The cement replacement by fly ash was varied between 0 to 50%. Cube specimens for sorptivity measurement cured in water for 28 days after casting. Concrete mixes having 1:1.57:1.35:2.03 (Cement: Sand: 10mm Aggregates: 20mm Aggregates.) proportions having 0.55, 0.475, 0.40 and 0.34 w/c ratios were used. The cement replacement by fly ash was kept at 0%, 10%, 20%, 30%, 40% and 50% of total cement content (by weight) for each w/cm ratio. Results show that Concretes having the higher volume of cement replacement by fly ash showed lower values of cumulative water absorption indicating lower porosity in the cover zone. Also Concretes with lower w/cm ratio have lower water absorption for all the mixtures. The sorptivity values are least due to the lower amount of water in the mix, resulting in lower porosity. Concretes with lower w/cm ratio have lower water absorption for all the mixtures. The sorptivity values are least due to the lower amount of water in the mix, resulting in lower porosity.[3].

Salmabanu Luhar, Urvashi Khandelwal used geo polymer concrete (GPC) specimens for compressive strength and change in the mass test for cubes of control concrete,3 specimens for each test were prepared compressive strength and change in mass to take average result of the specimen. The samples were pre-conditioned for 7 days in the hot air oven at 500 C. The sides of the specimen were sealed in order to achieve unidirectional flow. Locally available wax and resin with 50:50 proportions was used as the sealant. Weights of the specimen after sealing were taken as initial weight. The initial mass of the sample was taken and at time 0 it was immersed to a depth of 5-10mm in the water. At selected times (typically 1, 2,3, 4, 5,9, 12, 16, 20 and 25 minutes) the sample was removed from the water, the stop watch stopped, excess water blotted off with a damp paper towel or cloth and the sample weighed. Then replaced by water and stop watch was Started again. The mix design of M25 geo polymer concrete was used in the study. The results were compared to that of control concrete. It was found that the Sorptivity curve is less linear as compared to that of control concrete. That means the rate of absorption of geo polymer is less. Test results of Water absorption test show that the porosity of geo polymer concrete is less as fly ash is fine ethanoic and results into less water absorption than the control concrete [4].

A preliminary study presenting the influence of surface finish on sorptivity characteristics. Ordinary Portland cement (ASTM C150, type 1) was used throughout. Coarse and fine aggregates were selected in accordance with ASTM C33, with the course aggregate being a crushed gravel conforming to ASTM No.67. Samples were cast as 300 mm x 150 mm cylinders in accordance with ASTM C192 and vibration compacted in three approximately equal layers. All samples received similar compaction procedures. The top surface of each sample was troweled level with the top far of the mould with a steel trowel. After curing for 7 days by using the water cooled diamond saw cut in half parallel to the top and bottom surfaces with a water-cooled diamond saw. And performed the sorptivity test on those specimens among those it is observed that cut surface has less sorptivity than other surfaces [5].

SORPTIVITY

Sorptivity defined as a measure of the capacity of the medium to absorb or desorb liquid by capillarity. According to C Hall and W D Hoff, the sorptivity expresses the tendency of a material to absorb and transmit water and other liquids by capillarity. The sorptivity is widely used in characterizing soils and porous construction materials such as brick, stone, and concrete. Calculation of the true sorptivity required numerical iterative procedures dependent on soil water content and diffusivity. John R. Philip (1969) showed that sorptivity can be determined from horizontal infiltration where water flow is mostly controlled by capillary absorption:

$$I=S\sqrt{t},$$

where S is sorptivity and I is the cumulative infiltration (i.e., distance) at time t. Its associated SI unit is m•s-1/2.

Minimizing sorptivity is important in order to reduce the ingress of deleterious materials which can cause extensive damage to a structure. Generally, concrete structures in cold climates are subjected to combinations of freeze-thaw deterioration and the corrosion of steel reinforcement due to the ingress of chlorides from deicing salts. In these environmental conditions, entire structures are susceptible to early deterioration, which can induce unnecessary costs. Also, many building materials used in the construction industry are porous. The ingress of moisture and the transport properties of these materials have become the underlying source for many engineering problems such as corrosion of reinforcing steel, and damage due to freeze-thaw cycling or wetting and drying cycles.

MATERIALS AND PROPERTIES:

Cement

Ordinary Portland cement (Grade 43) was used.Its physical properties are as given in Table1.

Table 1. Physical Properties of Cement

Physical property	Results obtained
Fineness (retained on 90µ seive)	5%
Normal Consistency	32%
Vicat initial setting time (minutes)	50
Vicat final setting time (minutes)	275
Compressive strength 28days(MPa)	43.6
Specific gravity	3.09

Aggregates & Admixtures

Crusher dust: The bulk density of Crusher dust (loose state) is1292kg/m3 and rodded state is 1516kg/m3. : Locally available free of debris from nearby Crushers. Crusher dust is used as fine aggregate. In the present study, the Crusher dust conforms to zone III is used. The specific gravity is 2.65.

Coarse Aggregates: The crushed aggregates used were 10mm nominal maximum size and are tested as per Indian standards6 and results are within the permissible limit. The specific gravity of coarse aggregate is 2.73; the bulk density of coarse aggregate (loose state) is 1783kg/m3 and rodded state is 1850kg/m3.

Water: Water available in the college campus conforming to the requirements of water for concreting and curing

Fly Ash: Fly ash was collected from the thermal power plant. The ash was grounded before using and used as a cement replacement material. Fineness is 97% , Specific gravity 1.68 chemical properties are given in Table-2

Rice husk Ash[RHA]: This was obtained from the Andhra cement in Visakhapatnam located at 150 km away from the college its Fineness is 96% , Specific gravity 2.77. chemical properties are given in Table-2

Wood husk Ash[WHA]: It is obtained from the nearby brick industries which is being used for the burning the bricks.the ash was grounded before using in the same manner as a cement replacement material.Fineness is 92% , Specific gravity 2.70. chemical properties are given in Table-2.

TABLE 2: Chemical Properties oF Fly Ash6, Rice Husk Ash6, WHA*

Composition	Proportion (%)		
	Fly ash	Rice Husk Ash	Wood husk Ash*
SiO2	53.76	33.34	12.56
CaO	1.48	40.97	6.43
Fe2O3	0.62	0.37	Nil
Al2O3	1.89	10.50	16.74
MgO	2.06	9.03	4.32

* Chemical compositions are analyzed in the chemical department of the college.

EXPERIMENTAL SETUP AND PROCEDURE

The experimental work consists of performing the sieve analysis of Fly ash, Rice Husk Ash, WHA as per the Indian standard procedure and using the resultant for the mix design to achieve the concrete of required strength and quality. Thereafter the concrete is tested for workability parameters by performing the slump cone test on it, followed by casting the cubes of concrete for further investigations. For carrying out sorptivity test a total 56 number of 100mm side concrete cubes were cast.

Table-3: Properties of Fresh Concrete

Sample Designation	Mix proportion Cement, Kg/m3	Fly Ash %by wt (kg/m3)	Wood husk Ash [WHA] % by wt (kg/m3)	Rice Husk Ash [RHA] % by wt (kg/m3)	Course Aggregate 10mm (Kg/m3)	Crusher Dust (Kg/m3)	W/C ratio	Dosage of Super plasticizer (L/m3)	Slump (mm)
M25									
Type-1	320	-	-	-	1360	654	0.50	3.6	25
Type-2	288	10% (32kg)	-	-	1360	654	0.50	3.6	10
Type-3	288	-	10% (32kg)	-	1360	654	0.50	3.6	20
Type-4	288	-	-	10% (32kg)	1360	654	0.50	3.6	12
M30									
Type-1	367	-	-	-	1155	721	0.49	3.8	20
Type-2	331	10% (36kg)	-	-	1155	721	0.49	3.8	15
Type-3	331	-	10% (36kg)	-	1155	721	0.49	3.8	21
Type-4	331	-	-	10% (36kg)	1155	721	0.49	3.8	17
M35									
Type-1	440	-	-	-	1060	754	0.40	4.0	19
Type-2	396	10% (44kg)	-	-	1060	754	0.40	4.0	10
Type-3	396	-	10% (44kg)	-	1060	754	0.40	4.0	24
Type-4	396	-	-	10% (44kg)	1060	754	0.40	4.0	16

SORPTIVITY TEST

The utility of sorptivity measurement for service life predictions was performed using the Sorptivity Test. Briefly, in this test, a concrete core specimen is placed in a pan and exposed to a liquid on one plane. The liquid in the pan is kept constant to avoid discrepancies due to pressure gradients. At regular intervals, the mass of the concrete core specimen is weighed and the amount of fluid absorbed is normalized by the cross-sectional area of the exposed surface. Then draw a graph between the rate of absorption and the square root of time. The slope of this graph gives sorptivity values. A lower sorptivity value indicates good quality material and higher sorptivity values indicate material of poor quality.

Initially, water tight pan of large capacity to accommodate the specimens is taken. Now apply paraffin wax to the specimens to all the sides expect the side which exposed to water. Note down the initial weights of all the specimens. Place the support device at the bottom of the pan and fill the pan with tap water so that the water level is 1 to 3 mm above the top of the support device. Maintain the water level 1 to 3 mm above the top of the support device for the duration of the test.Start the timing device and immediately place the test surface of the specimen on the support device Record the time and date of initial contact with water. Measure the weights of specimens at suitable intervals.

For each mass determination, remove the test specimen from the pan, stop the timing device and blot off any surface water with a dampened paper towel or cloth. After blotting to remove excess water, invert the specimen so that the wet surface does not come in contact with the balance pan (to avoid having to dry the balance pan). Measure the mass to the nearest 0.01 g. immediately replace the specimen on the support device and restart the timing device.

The absorption, I, is the change in mass divided by the product of the cross-sectional area of the test specimen and the density of water.

i = change in mass /(cross section area *density of water)

For the purpose of this test, the temperature dependence of the density of water is neglected and a value of 0.001 g/mm3 is used. The units of I are mm.

Sorptivity test on concrete blocks:

From concrete mix proportion as shown in Table-3 12 cubes of 3, each type is cured for 7 days before performing sorptivity test on it. Sorptivity test on concrete blocks are performed according to ASTM C1585-04 with paraffin wax as sealant in suitable intervals.

Fig 1: Mixing process of concrete

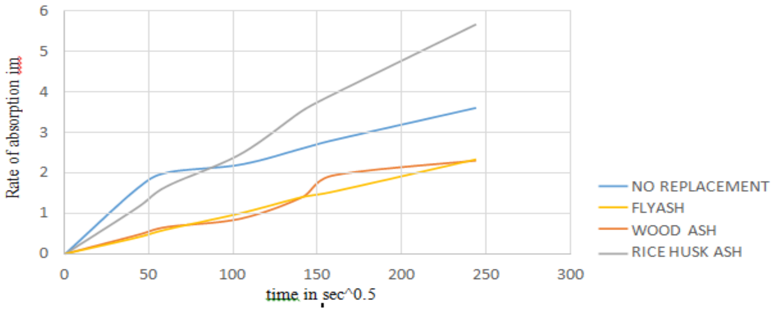
Fig 2: Cubes after casting

Fig 3: Sorptivity test setup of concrete blocks

RESULTS AND DISCUSSIONS

TABLE 4: Sorptivity Results for M25 grade concrete blocks

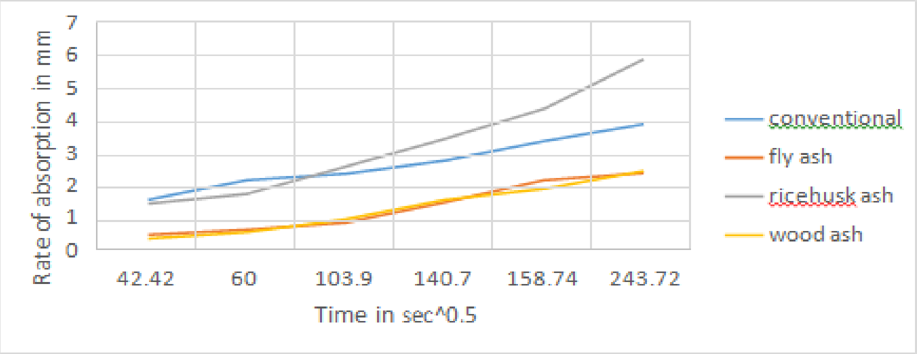
Time in sec	Rate of absorption in mm				Sorptivity (mm/sec$^{0.5}$)			
T	Type - 1(conventional)	Type-2	Type-3	Type-4	Type- 1	Type- 2	Type- 3	Type-4
1800	1.6	0.46	1.13	0.4	0.037	0.0110	0.0265	0.00937
3600	2	0.66	1.66	0.6	0.033	0.0111	0.0275	0.00996
10800	2.2	0.866	2.46	1.00	0.0214	0.00833	0.0236	0.0096
19800	2.6	1.40	3.53	1.40	0.0184	0.0099	0.0247	0.0096
25200	2.8	1.93	3.93	1.53	0.01764	0.01215	0.0247	0.0095
59400	3.6	2.3	5.66	2.33	0.0147	0.009	0.0236	0.0095
Average					0.0236	0.010	0.0251	0.00953



Graph showing rate of absorption Vs time for M25 grade concrete

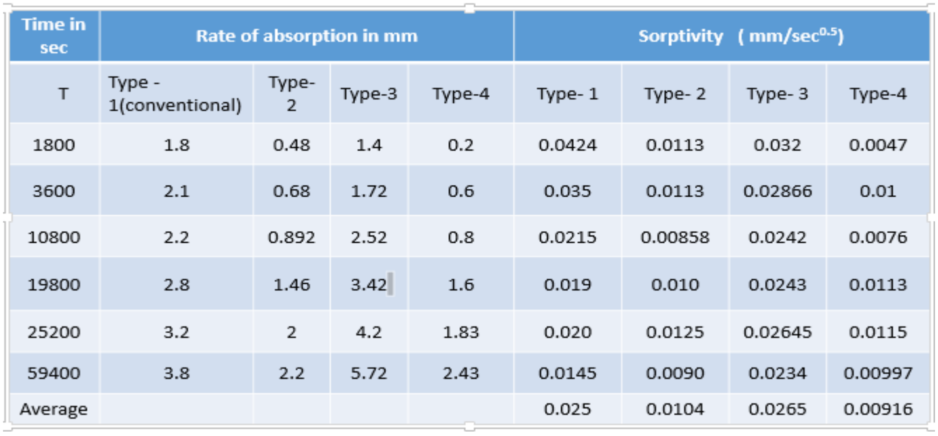
TABLE 5: Sorptivity Results for the M30 grade of concrete blocks.

Time in sec	Rate of absorption in mm				Sorptivity (mm/sec$^{0.5}$)			
T	Type - 1(conventional)	Type-2	Type-3	Type-4	Type- 1	Type- 2	Type- 3	Type-4
1800	1.6	0.52	1.48	0.4	0.0377	0.0122	0.0348	0.00942
3600	2.2	0.68	1.78	0.6	0.0366	0.0113	0.0296	0.01
10800	2.4	0.89	2.62	1	0.0230	0.00856	0.02966	0.0166
19800	2.8	1.52	3.48	1.6	0.0198	0.0108	0.0247	0.00952
25200	3.4	2.2	4.4	1.93	0.0214	0.013	0.0277	0.0121
59400	3.92	2.42	5.92	2.48	0.016	0.0092	0.0242	0.0101
Average					0.0257	0.0108	0.0284	0.00926

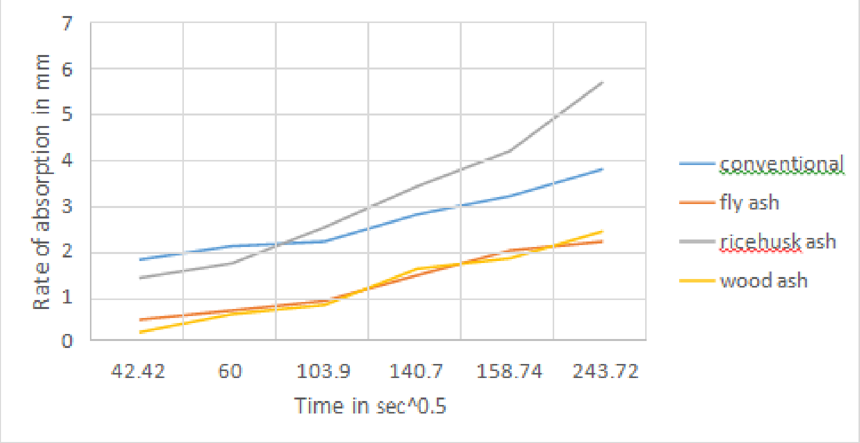


Graph showing rate of absorption Vs time for M30 grade concrete

TABLE 6: Sorptivity Results for M35 grade concrete blocks



Time in sec	Rate of absorption in mm				Sorptivity (mm/sec$^{0.5}$)			
T	Type - 1(conventional)	Type-2	Type-3	Type-4	Type- 1	Type- 2	Type- 3	Type-4
1800	1.8	0.48	1.4	0.2	0.0424	0.0113	0.032	0.0047
3600	2.1	0.68	1.72	0.6	0.035	0.0113	0.02866	0.01
10800	2.2	0.892	2.52	0.8	0.0215	0.00858	0.0242	0.0076
19800	2.8	1.46	3.42	1.6	0.019	0.010	0.0243	0.0113
25200	3.2	2	4.2	1.83	0.020	0.0125	0.02645	0.0115
59400	3.8	2.2	5.72	2.43	0.0145	0.0090	0.0234	0.00997
Average					0.025	0.0104	0.0265	0.00916



Graph showing rate of absorption Vs time for M35 grade concrete

CONCLUSION

- In all mix designs, concrete with cement replaced with wood ash has low sorptivity values compared to other types.
- Concrete with cement replaced with rice husk ash has high sorptivity values compared to other replacements.
- Slight Decrease in Sorptivity values is observed with increasing in the grade of concrete after 7 days of curing.
- For M25 grade concrete, compared to conventional concrete when replaced with fly ash has 52.6% lesser sorptivity, whereas 59.6% lesser for concrete with cement replaced with wood ash and 6.3% more sorptivity for rice husk ash replacement.
- For M30 grade concrete, fly ash replaced cement concrete has 52.9% lesser sorptivity than conventional whereas for wood ash replaced cement concrete has 63.96% lesser sorptivity than conventional.
- For M35 grade concrete, fly ash replaced cement concrete has 58.4% lesser than conventional concrete, whereas wood ash replaced cement concrete has 63.36% more sorptivity values compared to conventional concrete.

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